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SHEET (1)
Modes of Heat Transfer

1-The inner and outer surfaces of a (5x6) m^2 brick wall of thickness 30 cm and thermal conductivity 0.69 W/m.°C are maintained at temperature of 20 °C and 5°C, respectively. Determine the rate of heat transfer through the wall.

2-In an experimental for determine the thermal conductivity of a given metal, a specimen 2.5 cm in diameter and 15 cm long is heated to 100 °C at one end and cooled to 0 °C at the other end. If the cylindrical surface is completely insulated and electrical measurements show a heat flow of 3 watts. Determine the thermal conductivity of the specimen material.

3-A thermally insulated glass window 100 cm by 50 cm is made of two 4 mm thick pieces of glass sandwiching a 4 mm thick air space. Determine the conduction heat loss through the window for the surface temperature 50 °C, -10 °C. Take thermal conductivity of glass and air equals 0.7 and 0.026 W/m. °C respectivly.

4-Determine the temperature at both internal glass-air surfaces in problem (3) and neglect all convective heat transfer.

5-A furnace wall is made of three layers, one of fire brick, one of insulating brick and one of red brick the inner and outer surfaces are at 870 °C and 40 °C respectively, the respective coefficients of thermal conductivities of the layers are 1, 0.12 and 0.75 W/m.K and the thicknesses are 22 cm, 7.5 and 11 cm. Assuming close bonding of the layer at their interfaces, find the rate of the heat loss per square meter per hour and the interface temperatures.

6-Consider steady state conditions for one dimensional conduction in a plane wall having a thermal conductivity k = 50 W/m.K and thickness L = 0.25 m with no heat generation. Determine the unknowing quantities for each case in accompanying table and sketch the temperature distribution. Indicating of the heat flux.

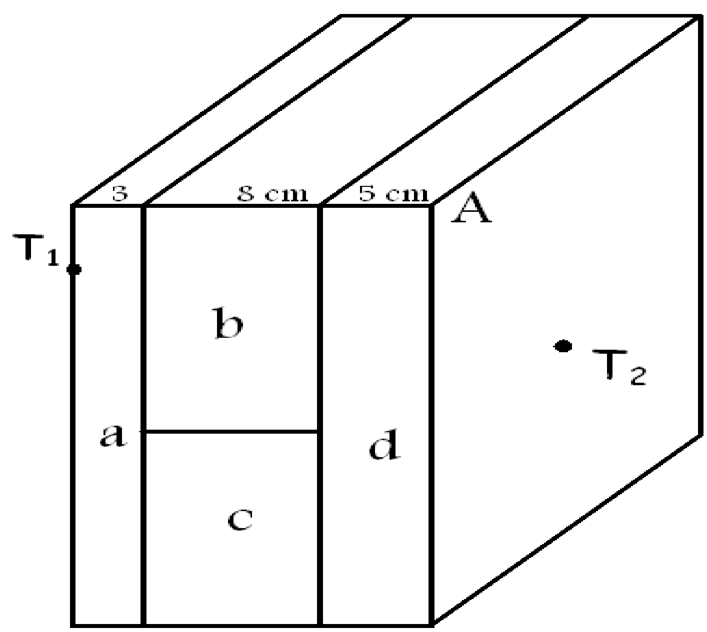
Case	T_1	T_2	dT / dx (K / m)	q = Q/A (W / m²)
1	400 k	300 k		
2	100 °C		-250	
3	80 °C		+200	
4		-5 °C		4000
5	30 °C			-3000

7-Determine the loss of heat through the wall of a rotating sphere shaped boiling pan with an inner diameter d_i = 1.5 m and total boiler wall thickness δ = 20 cm. The inner surface temperature is 200 °C and that of the outer surface T_2= 50 °C. The equivalent thermal conductivity is 0.12 W/m.K. Also find the heat flux at inside area.

8-An insulated steam pipe having outside diameter of 3 cm is to be covered with two layers of insulation each having a thickness of 2.5 cm. The average thermal conductivity of one material is 5 times that of the other. Assuming that the inner and outer surface temperatures of composite insulation are fixed, how much will the heat transfer be reduced when the better insulating material is next to the pipe than it is outer layer?

9-Find the heat transfer through the composite wall shown in figure per unit area. Assume one-dimensional heat flow, where:

k_a = 150 W/m.K k_b = 30 W/m.K,
k_c = 65 W/m.K k_d = 50 W/m.K
A_b = Ac = 0.5m² A_a = Ad = 1m²
T_1 =400 °C T_2 =60 °C



10-An exterior wall of a house consists of 10.2 cm brick (k = 0.7 W/m.K) and 3.8 cm gypsum plaster (k = 0.48 W/m.K). What thickness of loosely packed rock wool insulation (k= 0.065 W/m.K) should be added to reduce the heat transfer through the wall by 75%.

11-Steam at a temperature of 250 °C flows through a steel pipe (AISI 10*10) of 60 mm inside diameter and 75 mm outside diameter. The convection coefficient between the steam and inner surface of the pipe is 500 W/m^2°C, while that between the outer surface of the pipe and the surroundings is 25 W/m^2°C, the pipe emmisivity is 0.8 and the temperature of the air of surroundings is 20°C .

What is heat loss per unit length of the pipe? (Take k_p= 58 W/m.K)

12-The construction of a furnace wall consists of the following layers; 7.5 cm fire brick of thermal conductivity (k=1.1 W/m.K) and 0.64 cm mild steel plate of thermal conductivity (k = 39 W/m.K). The temperature inside the furnace is 920 K and that of the outside air is 300 k. the heat transfer coefficient on the outside surface is (h = 68 W/m^2.k). Determine the heat loss per unit area and the temperature of the outside surface. If in additional 18 bolts of 1.9cm diameter extended through the furnace wall, find the percentage increase in heat transfer.

13-Derive a relation for critical radius of insulation for a sphere.

14-Derive the expression for the thermal resistance through a hollow spherical shell inside radius r_i, and outside radius r_o having a thermal conductivity k.

15-A steam pipe of inner and outer diameters 1.6 and 1.7 cm respectively is covered by with two layers of insulation. The thickness of the first layer is 3 cm and that of the second layer is 5 cm. the thermal conductivity's of the pipe and insulating layers are 58, 0.174 and 0.093 W/m.K, respectively. The temperature of the inner surface of steam pipe is 300 °C, and that of the outer surface of the insulation layer is 50 °C. Determine the heat loss per meter and the layers constant temperatures.

16-Calculate the critical radius of insulation for asbestos (k=0.17 W/m. °C) surrounding a pipe and exposed to room air at 20 °C with (h = 3W/m^2°C), calculate also the heat loss per unit length from a 200°C, 5 cm diameter pipe when covered with critical radius of insulation and without insulation.

17-Water flow inside a steel pipe (k=43 W/m. °C) of 2.5 cm outer diameter. The wall thickness is 0.2mm the convective heat transfer coefficient on the inner side is 500 W/m^2. °C while on the outer side 0.12 W/m^2. °C. Calculate the overall heat transfer coefficient. If the pipe is covered with an asbestos layer (k=0.18 W/m.°C) while still surrounding by a convective environment with (h = 12 W/m^2. °C) .
Determine the critical insulation radius.

Will the heat transfer be increased or decreased by adding an insulation thickness:
a) 5 mm b) 10 mm?

18-The suction line of a refrigerator carries a refrigerant at -20 °C and surrounded by air at 20 °C, the pipe line is made of a steel tube of 50 mm inner diameter, 5 mm wall thickness and thermal conductivity of 58 W/m.K. If the inside and outside convective heat transfer coefficient is 2300 and 6 $W/m^2.k$ respectively, calculate:

a) The thickness of insulation which prevent water vapor to be condensed at the outer side, considering that the dew point of air is 15 °C.
b) The rate of heat transfer from air to the pipe per unit length if k_{ins} = 0.042 W/m.K.

19-A furnace of 60 by 90 by 120 cm out side dimensions is constructed from a material having a thermal conductivity of 0.865 W/m.°C. The wall thickness is 15 cm. The inner and the outer surface temperatures are 520 °C and 20 °C, respectively. Calculate the total heat loss through the furnace walls.